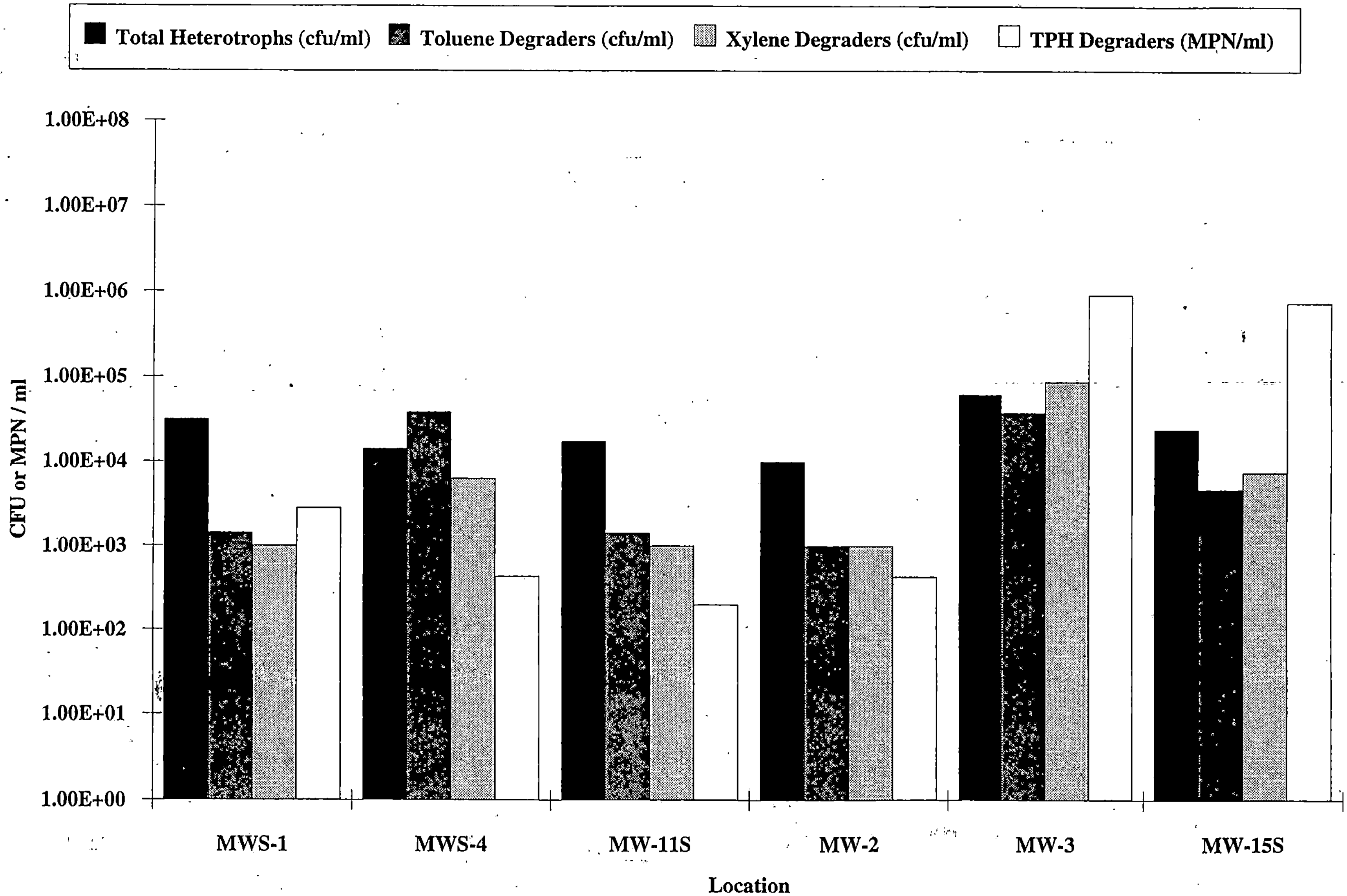

Figure 4. Results of the Microbial Enumerations Performed on the Groundwater Samples

AR340266

METHODOLOGY

GES utilized a vapor extraction and treatment unit (VR unit) manufactured by Vapor Recovery Systems, Inc.® to conduct the tests. The VR unit is an internal combustion engine capable of extracting vapors from a designated vapor recovery point at a maximum design air flow rate of 250 cubic feet per minute and is capable of producing a vacuum of 244 inches of water.

The vapors withdrawn from the extraction points are pulled back to the VR unit and destroyed in the internal combustion engine. If withdrawn hydrocarbon concentrations are high enough, the recovered vapors can be used as the sole source of fuel to run the engine. The system is completely automated and will supply supplemental fuel (propane) when hydrocarbon concentrations are not sufficient to run the system. The system is capable of removing up to 55 lbs/hr of hydrocarbons at a total destruction rate of 99.97%.

GES also utilized a Thermo Environmental Instruments® Model 580B Photoionization Organic Vapor Meter (OVM) to monitor influent volatile organic compounds (VOC) concentrations during the course of the tests. In addition, an explosimeter was used to monitor the lower explosive limit (LEL) of the influent air stream. An oxygen meter was used to monitor influent oxygen levels.

During each test, induced vacuum was monitored at monitoring wells surrounding the extraction points, or in temporary vapor monitoring points. The temporary monitoring points were constructed by hand-driving a 1/2-inch diameter steel rod approximately 48 inches below grade. After the rod was removed, a 30-inch long, 1/4-inch diameter copper tube was inserted into the hole. A 1-inch diameter rubber stopper, which slides over the tube was installed near the top of the copper tube. When the copper tube is inserted into the soil, the rubber stopper acts as a plug and a vacuum seal. Soil pressure and soil gas can also be monitored through this tube.

During the first test, conducted on 4 May on RW-2, vacuum was monitored at existing wells S-1, S-2, and S-4. This test was conducted near the area where solvent first discharged to the ground surface during the 26 November 1986 solvent spill. During the second test, conducted on 5 May on MW-10, vacuum was monitored at wells MW-19, and MW-20, and in vapor monitoring points VP-1, VP-2, VP-3, and VP-4. Note that wells MW-19 and MW-20 were installed specifically for use during this test. This test was conducted approximately 200 feet down gradient of RW2. Prior to conducting the third test, two additional vapor points (VP-5 and VP-6) were installed (Figure 3). On 10 May, during the third test, vacuum was induced simultaneously on RW-2 and MW-10. During this test, VP5, VP6, and S3 were monitored in addition to the above mentioned points.

On Wednesday, 4 May 1994, a high-vacuum extraction pilot test was conducted on recovery well RW-2 for 4.5 hours. Well RW-2 was outfitted with a specially designed air-tight cap that would enable water removal via a submersible pump at the same time the VR unit was pulling a vacuum on the well. Vacuum gauges were deployed on surrounding wells S-1, S-2, and S-4 to monitor remote vacuum influence at each of these points. The distances to the surrounding wells from RW-2 ranged from 16 to 36 feet. The water pumping rate from RW-2 was also monitored. Vacuum readings and water flow rates were taken and recorded every half hour throughout the test. The tabulated results from this test can be found in Tables 1 and 4. Figure 1 depicts the vacuum influence induced during the test.

On Thursday, 5 May 1994, a four-hour pilot test was conducted on MW-10. This test was set up the same way as the test performed on RW-2. Vacuum gauges were deployed on two surrounding wells, MW-19 and MW-20, and four surrounding vapor points, VP-1, VP-2, VP-3 and VP-4. The distance to these points ranged from 15 to 26.5 feet. Again, vacuum and water flow rates were taken and recorded every half hour throughout the testing period. The tabulated results from this test can be found on Tables 2 and 4. Figure 2 depicts the vacuum influence induced during the test.

On Tuesday, 10 May 1994, a seven and one half-hour pilot test was conducted simultaneously on RW-2 and MW-10. The purpose of this test was to gather additional data specific to operation of two simultaneous withdrawal points. This test was performed in the same manner as the first two tests, except that the VR unit was set up to produce a vacuum on both wells at the same time. All of the monitoring points used to conduct the first two tests were used again along with the two additional vapor points, VP-5 and VP-6, and well S-3. These wells and vapor points were monitored for vacuum influence and the pumping rates of RW-2 and MW-10 were monitored and recorded every half hour. The results of this test can be found on Tables 3 and 4. Figure 3 depicts the range of vacuum influence induced during the test.

During all three tests, vacuum and the air flow readings at the VR unit were monitored and recorded.

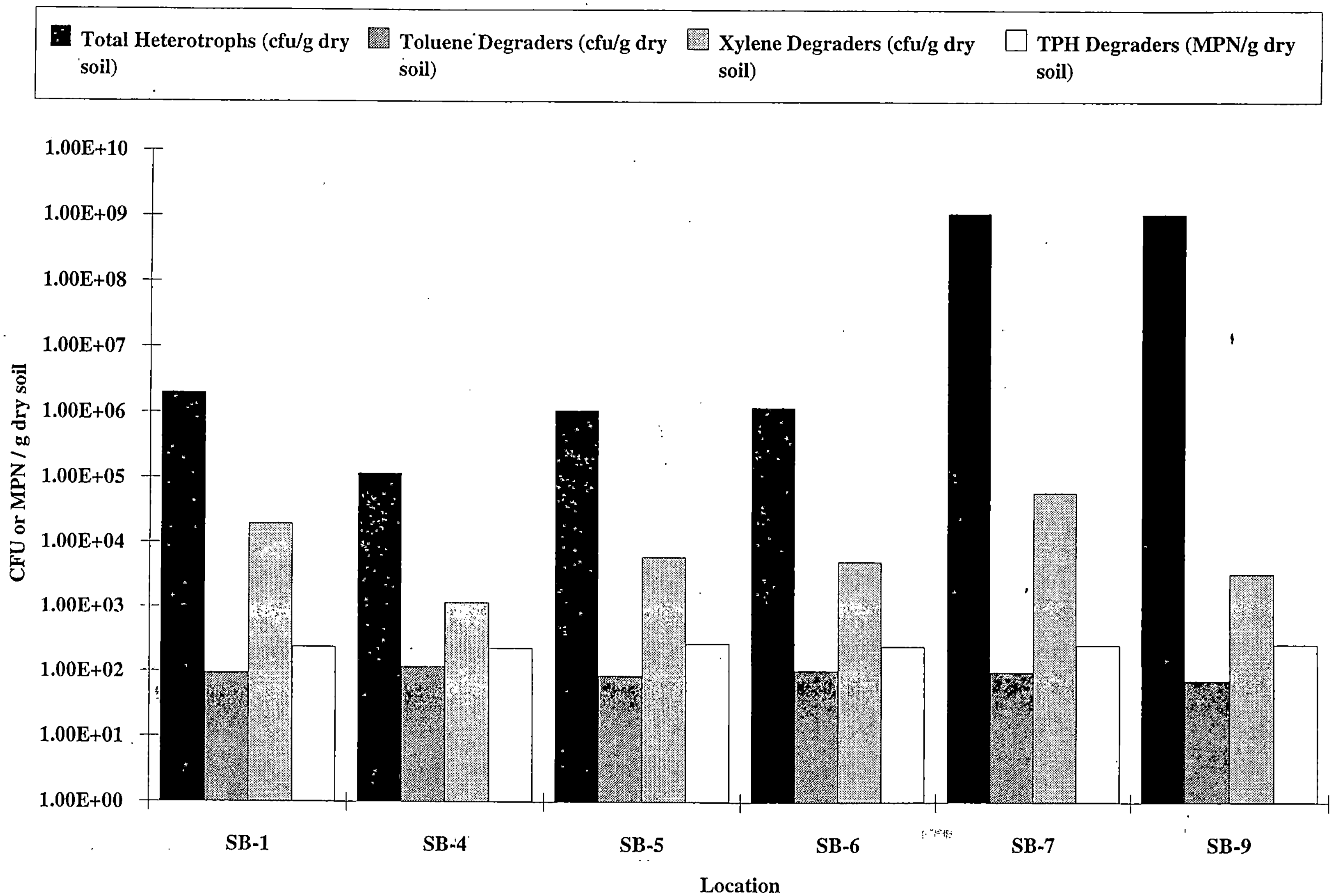

Figure 5. Results of the Microbial Enumerations Performed on the Soil Samples

AR340267

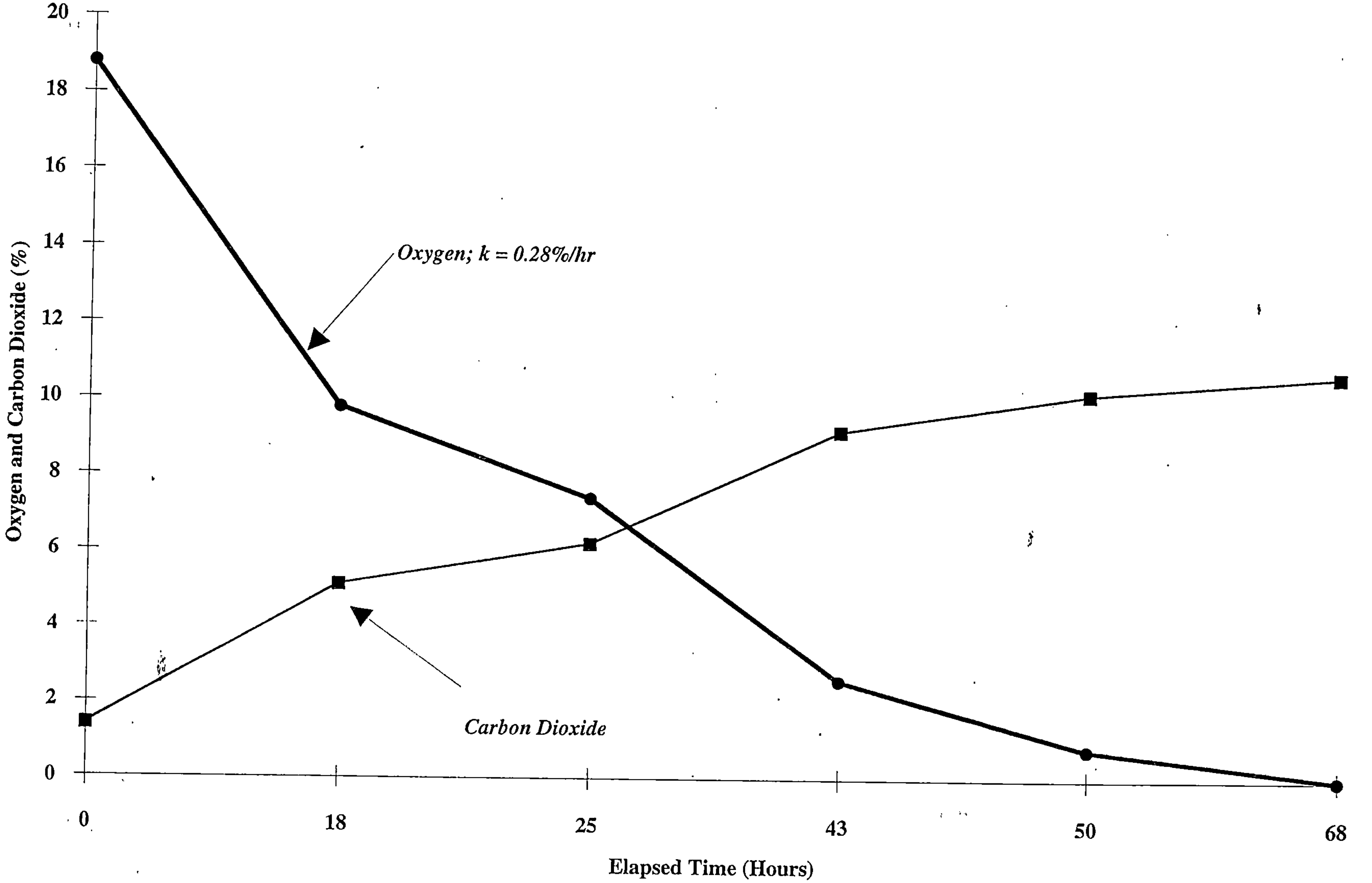

Figure 6. In Situ Respiration Test Results for Monitoring Point VP-6

Table 1. Bioremediation Groundwater and Soil Sampling Parameters

Groundwater

	Parameter	Comment
Microbial Enumerations	Total Heterotrophs	Spread Plate on Trypticase Soy Agar; 14 day incubation at room temperature
	Toluene Degraders	Spread Plate on Bushnell-Haas Agar in an atmosphere. of tol. vapors; 14 days incub. at room temp.
	Xylene Degraders	Spread Plate on Bushnell-Haas Agar in an atmosphere of xyl. vapors; 14 days incub. at room temp.
	TPH Degraders	Sheen Screen Most Probable Number with #2 Fuel Oil as Carbon and Energy Source
Organic Analyses	Total Organic Carbon	Determined by U.S. EPA method 415.1
	Benzene	Determined by U.S. EPA method 5030A/8021 (GC)
	Toluene	Determined by U.S. EPA method 5030A/8021 (GC)
	Ethylbenzene	Determined by U.S. EPA method 5030A/8021 (GC)
	m/p Xylene	Determined by U.S. EPA method 5030A/8021 (GC)
	o - Xylene	Determined by U.S. EPA method 5030A/8021 (GC)
Inorganic Analyses	Nitrate	Determined using a Corning pH/ISE meter and Orion Nitrate Electrode
	Ammonia	Determined by U.S. EPA method 350.2
	Phosphate	Determined by U.S. EPA method 365.2
	Iron	Determined using TPTZ reagent
	Sulfate	Determined by U.S. EPA method 415.1
Other	pH	Determined using a Corning pH/ISE meter and combination electrode

Soil

	Parameter	Comment
Microbial Enumerations	Total Heterotrophs	Spread Plate on Trypticase Soy Agar; 14 day incubation at room temperature
	Toluene Degraders	Spread Plate on Bushnell-Haas Agar in an atmosphere. of tol. vapors; 14 days incub. at room temp.
	Xylene Degraders	Spread Plate on Bushnell-Haas Agar in an atmosphere of xyl. vapors; 14 days incub. at room temp.
	TPH Degraders	Sheen Screen Most Probable Number with #2 Fuel Oil as Carbon and Energy Source
Organic Analyses	Benzene	Determined by U.S. EPA method 5030A/8021 (GC)
	Toluene	Determined by U.S. EPA method 5030A/8021 (GC)
	Ethylbenzene	Determined by U.S. EPA method 5030A/8021 (GC)
	m/p Xylene	Determined by U.S. EPA method 5030A/8021 (GC)
	o - Xylene	Determined by U.S. EPA method 5030A/8021 (GC)
Inorganic Analyses	Nitrate	Determined on aqueous soil extracts using Cadmium Reduction
	Ammonia	Determined on aqueous soil extracts using direct Nesserlization
	Phosphate	Determined on Bray's extracted soils using the molybdate technique
Other	pH	Determined using a Corning pH/ISE meter and combination electrode on soil slurries
	Soil Moisture	Determined by the difference between wet and air dry weights

GES

Table 2. Summary of the Groundwater Sampling Results for the Railroad and Tank Field Areas

		Total Heterotrophs (cfu/ml)	Toluene Degraders (cfu/ml)	Xylene Degraders (cfu/ml)	TPH Degraders (MPN/ml)	TOC (ppm)	Benzene (µg/l)	Toluene (µg/l)	Ethylbenzene (µg/l)	m/p Xylene (µg/l)	o - Xylene (µg/l)	Total Xylenes (µg/l)
Railroad Area	MWS-1	3.16E+04	1.41E+03	1.00E+03	2.80E+03	143.40	22	14,000	190	980	260	1,200
	MWS-4	1.41E+04	3.87E+04	6.33E+03	4.30E+02	77.85	9.7	83,000	480	2,200	660	2,900
	MW-11S	1.73E+04	1.41E+03	1.00E+03	2.00E+02	13.65	ND	ND	ND	ND	ND	ND
Tank Feld Area	MW-2	1.00E+04	1.00E+03	1.00E+03	4.30E+02	27.40	ND	1.3	ND	1.7	ND	1.7
	MW-3	6.32E+04	3.87E+04	8.94E+04	9.30E+05	43.93	3.4	1,900	66	500	130	630
	MW-15S	2.45E+04	4.69E+03	7.55E+03	7.50E+05	39.28	ND	ND	ND	ND	ND	ND

		pH	Nitrate (ppm)	Ammonia (ppm)	Phosphate (ppm)	Iron (ppm)	Sulfate (ppm)
Railroad Area	MWS-1	6.78	1.82	0.22	0.20	1.10	ND
	MWS-4	6.19	1.33	1.02	0.47	>1.98	24.5
	MW-11S	6.02	1.48	1.31	0.41	>1.98	56.0
Tank Field Area	MW-2	6.21	0.70	0.06	0.16	>1.98	48.0
	MW-3	6.83	1.20	0.23	0.25	>1.98	28.5
	MW-15S	7.36	1.05	0.07	0.21	>1.98	25.0

Notes:
cfu - colony-forming-unit
ml - millilter
MPN -most probable number
ppm - parts per million
µg - microgram
l - liter
ND - less than the minimum detection limit

Table 3. Summary of the Soil Sampling Results for the Railroad and Tank Field Areas

		Total Heterotrophs (cfu/g dry soil)	Toluene Degraders (cfu/g dry soil)	Xylene Degraders (cfu/g dry soil)	TPH Degraders (MPN/g dry soil)	Benzene (µg/Kg)	Toluene (µg/Kg)	Ethylbenzene (µg/Kg)	m/p Xylene (µg/Kg)	o - Xylene (µg/Kg)	Total Xylenes (µg/Kg)
Tank Field Area	SB-1 7' - 9'	1.99E+06	9.50E+01	1.96E+04	2.37E+02	ND	9.7	ND	ND	ND	ND
	SB-4 5' - 7'	1.17E+05	1.19E+02	1.17E+03	2.30E+02	ND	15,000	380	1,400	390	1,800
	SB-5 11'- 13'	1.10E+06	8.70E+01	6.02E+03	2.73E+02	ND	2,100	77	390	130	510
Railroad Area	SB-6 9' - 11'	1.20E+06	1.05E+02	5.11E+03	2.49E+02	ND	28,000	1,800	8,100	2,100	10,000
	SB-7 8' - 10'	1.12E+09	1.02E+02	6.11E+04	2.69E+02	ND	11	ND	ND	ND	ND
	SB-9 9' - 11'	1.09E+09	7.60E+01	3.45E+03	2.75E+02	ND	6.0	ND	ND	ND	ND

		pH	Nitrate (mg/Kg)	Ammonia (mg/Kg)	Phosphate (mg/Kg)	Moisture (%)
Tank Field Area	SB-1 7' - 9'	6.0 - 7.0	2	114	68	21.0
	SB-4 5' - 7'	6.0 - 7.0	6	56	52	23.4
	SB-5 11'- 13'	6.0 - 7.0	37	51	90	17.4
Railroad Area	SB-6 9' - 11'	6.0 - 7.0	8	77	37	16.9
	SB-7 8' - 10'	6.0 - 7.0	3	76	104	10.3
	SB-9 9' - 11'	6.0 - 7.0	26	83	34	16.6

Notes:
cfu - colony-forming-unit
g - gram
MPN -most probable number
ppm - parts per million
µg - microgram
Kg - kilogram
ND - less than the minimum detection limit

Table 4. Summary of Soil Gas Sampling Results

Date	Time		VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
5/23/94	8:20 AM	% Oxygen	16.8	20.6	20.6	20.1	20.4	1.2	20.8
		% Carbon Dioxide	2.6	0.1	0.1	0.9	0.8	8.1	0.2
		% Methane	6.9	0.3	0.1	0.1	0.3	54.5	0.7

Table 5. In Situ Respiration Test Monitoring Results

Date	Time	
5/25/94	1:30 PM	Began VR Test on Wells 1E and 3 (Ran 8 Hours)

5/25/94 2:30 PM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	19.9	19.9	20.8	19.5	20.0	20.7	20.5
% Carbon Dioxide	0.6	0.4	0.0	0.6	0.4	0.0	0.3
% Methane	0.4	0.2	0.1	0.4	0.1	0.1	0.1

5/25/94 5:30 PM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	19.4	19.5	19.9	19.9	20.2	20.4	19.8
% Carbon Dioxide	0.3	0.3	0.2	0.6	0.1	0.0	0.6
% Methane	0.1	0.0	0.0	0.0	0.0	0.0	0.0

5/25/94 9:30 PM VR Test Ends

5/25/94 10:00 PM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	19.7	19.0	19.5	19.6	19.5	19.2	19.4
% Carbon Dioxide	0.2	0.4	0.3	0.8	0.4	0.4	0.3
% Methane	0.3	0.0	0.0	0.0	0.0	0.0	0.0

5/26/94 10:30 AM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	19.1	19.3	19.3	19.3	19.5	14.4	19.6
% Carbon Dioxide	0.6	0.2	0.2	0.1	0.1	2.7	0.3
% Methane	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5/26/94 12:30 PM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	18.9	19.4	19.3	19.3	19.0	10.9	19.2
% Carbon Dioxide	0.4	0.2	0.2	0.1	0.3	3.9	0.6
% Methane	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5. continued

5/27/94 10:00 AM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	18.8	19.3	19.5	19.4	19.9	12.4	19.6
% Carbon Dioxide	0.4	0.2	0.2	0.9	0.0	3.7	0.4
% Methane	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5/27/94 10:47 AM Began VR Test on MW-1E, Ran for 1 hr 45 min.

5/27/94 1:18 PM Began VR Test on MW-3, Ran for 2 hrs 4 min.

5/27/94 4:00 PM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	19.5	19.9	20.1	20.2	20.1	18.8	20.1
% Carbon Dioxide	0.3	0.2	0.1	0.1	0.1	1.4	0.6
% Methane	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5/28/94 10:00 AM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	19.2	19.2	19.3	19.6	19.5	9.8	19.6
% Carbon Dioxide	0.3	0.2	0.2	0.1	0.1	5.1	0.6
% Methane	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5/28/94 5:00 PM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	19.4	9.5	19.7	19.6	19.7	7.4	19.6
% Carbon Dioxide	0.2	0.1	0	0.1	0.1	6.2	0.6
% Methane	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5/29/94 11:00 AM

	VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
% Oxygen	18.2	18.6	18.7	18.7	18.8	2.6	19.5
% Carbon Dioxide	0.9	0.2	0.2	0.2	0.2	9.2	0.4
% Methane	0.0	0.0	0.0	0.0	0.0	0.0	0.0

VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7

5/29/94	6:00 PM	% Oxygen	19.3	19.3	19.3	19.3	19.1	0.8	19.0
		% Carbon Dioxide	0.1	0.1	0.1	0.1	0.4	10.2	0.6
		% Methane	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5. continued

			VP-1	VP-2	VP-3	VP-4	VP-5	VP-6	VP-7
5/30/94	12:00 PM	% Oxygen	19.3	19.3	19.4	19.3	18.9	0.0	19.8
		% Carbon Dioxide	0.0	0.0	0.0	0.2	0.6	10.7	0.4
		% Methane	0.0	0.0	0.0	0.0	0.0	3.2	0.0

Terra Systems
INCORPORATED

BIOVENTING FEASIBILITY STUDY

FOR THE QUEBECOR, INC. SITE

ATGLEN, PENNSYLVANIA

PREPARED FOR:

GROUNDWATER & ENVIRONMENTAL SERVICES, INC.
410 EAGLEVIEW BLVD., SUITE 110
EXTON, PENNSYLVANIA 19341

PREPARED BY:

TERRA SYSTEMS, INC.
1035 PHILADELPHIA PIKE, SUITE E
WILMINGTON, DELAWARE 19809

JULY 27, 1994

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EXECUTIVE SUMMARY

A bioremediation treatability assessment study was conducted for the hydrocarbon contaminated soil at the Quebecor, Inc. site in Atglen, Pennsylvania at the request of Groundwater & Environmental Services, Inc. (GES). A soil and groundwater sample from the site were subjected to feasibility studies by Terra Systems, Inc. (TSI) on behalf of GES to evaluate bioventing. Terra Systems concludes the following:

1. There were high counts of both heterotrophic (1.8×10^6 colony-forming-units/gram <cfu/g>) and hydrocarbon-utilizing (2.8×10^6 cfu/g) microbes in the initial soil samples indicating that conditions were favorable for microbial growth. These high counts are also an indication that the microbial population was acclimated to biodegrading the organic contaminants.

2. Soil samples contained low concentrations of toluene and ethylbenzene.

3. Soil venting alone appeared to be a viable remedial alternative for the unsaturated soils contaminated with petroleum hydrocarbon at the Quebecor site based upon the in situ bioventing treatability study. Soils from the area studied showed a 96 percent reduction in toluene over the six week study.

4. It does not appear that traditional in situ bioremediation will be appropriate at this site because of the potential soil plugging that will occur if nutrient enriched groundwater is injected into the formation.

1.0 INTRODUCTION

Groundwater & Environmental Services, Inc. (GES) engaged Terra Systems, Inc. (TSI) to investigate the feasibility of using bioventing to remediate organic contaminated soils at the Quebecor, Inc. site in Atglen, Pennsylvania. The organic contaminant of concern is reported to be toluene.

Bioventing is a process that promotes the activity of the native soil microbes to biodegrade the organic contaminants to carbon dioxide, cell mass, water, and salts by overcoming limitations on their growth. Bioventing supplies oxygen to the contaminated soil in the vadose zone by injecting air or by pulling air into the contaminated soil with vacuum extraction. For the option with vacuum extraction, the volatiles can be collected and captured on activated carbon or destroyed with a thermal treatment unit. At slow air injection rates, biodegradation of the contaminants can occur in the vadose zone before a receptor will be impacted. Both bioventing and vacuum extraction use similar equipment, but the major difference between the two is that the air flow rate in bioventing is limited to optimize biodegradation of the contaminants rather than volatilization. Bioventing can also treat compounds with a lower vapor pressure than can vacuum extraction because the microbes can attack these compounds and they will not partition into the vapor phase. For bioventing to be feasible, the organic contaminants must be biodegradable, and the soil microbial population must have developed the enzyme systems which will allow them to biodegrade the organic contaminants. To facilitate the process, the required inorganic nutrient (chiefly nitrogen and phosphate) are added to the soil, and the soil is aerated by venting. Moist soil conditions should be maintained to promote microbial growth.

A Shelby tube of soil was collected from the Atglen site at a depth of 7 to 9 feet below grade by G.E.S., Inc. The samples were shipped to the TSI Laboratory under chain-of-custody procedures. A copy of the completed chain-of-custody form is found in Appendix A. The soil sample was used to:

- Characterize the contaminants
- Determine if an active microbial population is present.
- Determine whether the microbes could biodegrade the contaminants.
- Determine if bioventing or vacuum extraction could remove the contaminants.
- Determine if a nutrient enriched groundwater solution would cause precipitation.

This report summarizes the results of this investigation and provides an evaluation of the potential effectiveness of bioventing or vacuum extraction to remediate the contaminated soil.

2.0 CONTAMINANT CHARACTERIZATION

2.1 METHODS

In preparing the column for the bioventing study, the top one inch of the soil within the Shelby tube was removed and discarded. A soil sample (approximately 300 grams) was then collected from the top of the column and analyzed for benzene, toluene, ethylbenzene, and xylenes according to the protocols for SWA 846 EPA Method 8020. This procedure uses a purge and trap unit to desorb the organics from the soil, collect them on a trap, and then expose them to a photoionization detector.

2.2 ORGANIC CONTAMINANT RESULTS

The initial soil sample contained <0.6 mg/kg benzene, 38 ug/kg toluene, 18 ug/kg ethylbenzene, 39 ug/kg m,p-xylene, and 7.5 ug/kg o-xylenes.

The concentrations of BTEX for the initial soil sample is summarized in Table 4 and the analytical reports are presented in Appendix A.

3.0 INORGANIC NUTRIENTS

3.1 INORGANIC NUTRIENT ANALYSES

A soil sample collected from the Atglen site at a depth of 7 to 9 feet below grade was analyzed for nitrate-nitrogen, total Kjeldahl nitrogen, phosphorus, zinc, sulfur, potassium, calcium, magnesium, pH, cation exchange capacity, organic matter, boron, iron, manganese, copper, sodium, salts, texture, and grain size distribution. MVTL Laboratories, Inc. of New Ulm, MN conducted these analyses.

Nitrogen, phosphorus, and oxygen are the primary nutrients required for biodegradation of hydrocarbons. Nitrate-nitrogen is an inorganic form of nitrogen readily available to most microbes. Nitrite-nitrogen is a reduced form of nitrate. High levels of nitrite would indicate that nitrate reduction was occurring in the soil. Total Kjeldahl nitrogen (TKN) is a measure of the organic nitrogen and ammonia in the soil. Zinc, sulfur, potassium, calcium, and magnesium are needed as minor nutrients. Boron, iron, manganese, copper and sodium are needed as trace minerals. The optimal pH for microbial growth is between 6 and 8. The cation exchange capacity is a measure of the ability of a soil to retain cations such as NH_4^+, K^+, Ca^{++}, and $Mg^{++}$from solution; soils with high clay or organic matter contents generally have higher cation exchange capacities. The organic matter in the soil is important in determining the nutrient requirements of a soil.

3.2 INORGANIC NUTRIENT RESULTS

The results of the inorganic analyses for the soil sample are presented in Table 1. The nitrate-nitrogen levels was 2.6 ppm. There was a relatively high TKN at 220 ppm. The phosphate level was 5 ppm. The potassium, zinc, sulfur, calcium, and magnesium levels were 10, 0.5, 26, 800, and 150 ppm respectively. The soil pH was 6.6. The trace minerals were boron at 0.2 ppm, iron 67.2 ppm, manganese 4.9 ppm, copper 0.7 ppm and sodium 13 ppm. The cation exchange capacity of the soil was 5.3 millequivalents per 100 grams. The organic matter was 2.3% which is considered to be low.

The particle size of the soil determined from the sieve analyses is reported in Table 2. The soil appeared to be predominantly a fine sand (54%) with some medium sand (19.2%), gravel (9.4%), coarse sand (4.2%), and moderately high clay and silt content (13.4%). (Please refer to Appendix A.)

3.3 INORGANIC NUTRIENT ANALYSES DISCUSSION

There appeared to be adequate levels of nitrogen and phosphorus in this soil to support the biodegradation of the relatively low levels of hydrocarbon contaminants detected in the soil. There appeared to be adequate levels of the minor and trace nutrients. The soil pH was 6.6

and should be within the optimal range for microbial growth.

3.4 SOIL CHARACTERIZATION

The particle size distribution of the soil suggests that bioventing or vapor extraction should be successful in this fine sand. Considering the clay content in the soil, the determination of the ability to move oxygen through the formation would need to be confirmed via a high vapor extraction test.

4.0 MICROBIAL ENUMERATIONS

4.1 METHODS

The soil sample was analyzed to enumerate heterotrophic bacteria and hydrocarbon-utilizing bacteria using standard microbiological plating techniques. The heterotrophic counts provided a measure of the total numbers of organisms in the soil capable of utilizing the organic compounds in nutrient agar as their substrate. Nutrient agar was prepared from beef extract and peptone and contains sugars, inorganic nutrients, vitamins, and their other components necessary for microbial growth. The heterotrophic counts were made using the pour-plate technique in which molten agar at approximately 45 ° C was poured over the dilutions of the sample and the agar allowed to solidify. The heterotrophic counts are made after incubation of the plates at 22° C for seven days. The hydrocarbon-utilizing population was enumerated by spread plating dilutions of the soil samples on a mineral medium with toluene as the only carbon source. The mineral medium contained washed agar and essential inorganic nutrients. The hydrocarbon-utilizers were counted after 26 days incubation at 22° C.

4.2 MICROBIAL COUNT RESULTS

The heterotrophic microbial counts, presented in Table 3, remained relatively constant during the feasibility study at an average of 3.0×10^7 colony-forming units per gram (cfu/g) considering the samples collected at times 8, 15, 28, and 42. This average is an increase from the initial counts of 1.8×10^6 cfu/g analyzed at time 0. The initial samples included two samples each from both the top and bottom of the column. There were high numbers (2.8×10^6 cfu/g) of hydrocarbon-utilizing microbes in the initial samples. Although the hydrocarbon-utilizers indicated a decreasing trend throughout the duration of the test, the counts remained within the acceptable range.

4.3 MICROBIAL COUNT DISCUSSION

There were high counts of both heterotrophic and hydrocarbon-utilizing microbes in the initial soil samples indicating that conditions were favorable for microbial growth. These high counts are also an indication that the microbial population was acclimated to biodegrading the organic contaminants.

The numbers of microbes in these samples may actually be much greater than found by these enumeration procedures. Generally only 1 to 10 percent of the microorganisms in an environmental sample will be enumerated on agar media. The enumeration procedures may underestimate microbial numbers because many of the microorganisms are not able to utilize the substrates in the media, reproduce too slowly to form colonies in the incubation period, were not detached from the soil, or for other reasons do not grow on the agar medium. The size of the microbial community would be expected to increase with oxygen and nutrient additions from the operation of the bioremediation system.

5.0 IN SITU BIOVENTING TREATABILITY STUDY

5.1 IN SITU BIOVENTING STUDY INTRODUCTION

A biodegradation study was set up to simulate the field operations of in situ bioventing. An intact column was operated at a low vacuum and amended with nutrients and water to simulate bioventing conditions. At the end of the study, groundwater from site well RW-1 enriched with nutrients was passed through the soil column to determine if plugging might be encountered.

5.2 IN SITU BIOVENTING STUDY METHODS

A soil column was set up using the soil sample provided by GES. The soil core was 2.75 in (7 cm) in diameter and 36 inches (91 cm) long. The column was prepared for the bioventing study by removing one inch (2.54 cm) of soil from both the top and bottom of the core. The column contained approximately 7,000 g of soil based on the 3,500 cm^3 of soil in the column and the density of 125 lb/ft^3 (2.0 g/cm^3). The soil removed from the top and bottom of the column was replaced with glass wool. A copper tube was inserted through the end cap and connected to a rubber stopper which was placed in 1 liter vacuum flasks. An adjustable vacuum source was used that had an air flow of 10 mL/min with a vacuum of 1 inch of water. An activated carbon trap (7.1 inch long by 0.6 inch diameter or 18 cm by 1.5 cm) containing 9.5 grams of carbon was placed between the column and the vacuum source to trap any volatiles that were removed during the bioventing process. The column was kept moist by passing air through a canister containing an aqueous solution of the nutrients (ammonia chloride and phosphate). The column was incubated at room temperature, approximately 22° C.

Samples were collected from the top of the column after 0, 8, 15, 28 and 42 days to be analyzed for BTEX by EPA Method 8020. Heterotrophic and hydrocarbon-utilizing bacteria were enumerated in samples from days -0-, 8, 15, 28, and 42. The percent moisture was determined at 0, 1, 2, 4, and 6 weeks by drying the soil in a 105° C oven overnight. All organic analyses have been corrected for percent moisture. The activated carbon traps were replaced after 15 and 42 days and analyzed for BTEX.

At the end of the bioventing study, groundwater enriched with nutrients was introduced onto the column to see what effects nutrient additions might have on the permeability of the soil. The groundwater, before introduction onto the column, was analyzed for pH, iron, and dissolved BTEX.

5.3 IN SITU BIOVENTING STUDY RESULTS

The volatile organic contaminants in the soil and activated carbon samples from the column study are presented in Tables 4 and 5 and Figure 1. Table 5 presents the mass balance for each volatile contaminant for the initial soil samples, the soil after treatment for six weeks, and the activated carbon trap. The mass balances for the soil samples assumed a quantity of 7,000 g. Each trap had 9.5 g of activated carbon. Based upon the information in Table 5, it appeared that the Day -0- sample (refer to Table 4) from the studies was not representative of the overall contamination levels at the site because of the much higher levels of volatile contaminants on the activated carbon trap than the initial soil. Also, there was a much higher level of m,p-xylene in the Day 8 sample (700 ug/kg) than the Day -0- sample (39 ug/kg) which also suggested that the Day -0- samples were not representative. Because of the high level of m,p-xylene detected in the Day 8 sample, a dilution had to be run and none of the other contaminants were detected.

There was an overall decline in the concentrations of volatile organics in the soil from Day -0- to Day 42. Benzene was not detected in the soil, although it was found at concentrations of 48,000 and 21,000 ug/kg on the activated carbon traps. Based on analytical results from other soil samples at the site, it appears that the benzene detected in the activated carbon trap could have resulted from lab contamination. Toluene was reduced from 38 to 3.8 ug/kg in the soil samples, a reduction of 90%. Ethylbenzene, m,p-xylenes, and o-xylenes were also removed to below the detection limit of <0.5 ug/kg in the Day 42 samples.

The heterotrophic and hydrocarbon-utilizing microbial counts over the course of the study are given in Table 3. The heterotrophic counts increased from 1.8×10^6 cfu/g to 1.8×10^8 cfu/g between the initial sample and the sample collected at Day 8. The heterotrophic counts then declined to 2.7×10^7 on Day 42. Counts of hydrocarbon-utilizers declined from 2.8×10^6 cfu/g on Day -0- to 8.0×10^5 cfu/g on Day 28. Hydrocarbon-utilizer counts from Day 42 were not available when this report was prepared.

The moisture content of the soil declined from the initial 20.2 percent to 15.3 percent on Day 42. The decrease in moisture content of the soil would likely reduce microbial activity somewhat, although these soils were still moist enough to support microbial activity.

A groundwater sample collected from RW-1 was used to test the effects of nutrient additions on the soil. This sample contained 25 mg/L iron, 22 ug/L benzene, 52,000 ug/L toluene, 460 ug/L ethylbenzene, 1,200 ug/L m,p-xylenes, and 410 ug/L o-xylene, and had a pH of 6.7. The column plugged after one pore volume of water had passed through the soil.

5.4 IN SITU BIOVENTING STUDY DISCUSSION

The mass balances on the activated carbon samples suggested that the majority of the removal that occurred was likely a result of volatilization, rather than biodegradation. Anomalies experienced during this test, including higher than anticipated VOCs absorbed in the carbon trap and benzene detected in the carbon trap but not in the soil sample, can not be readily explained. As noted, benzene detected in the carbon trap may be the result of laboratory contamination. The excessive concentrations of other VOCs detected in the carbon trap (see Table 4) could be partially influenced by laboratory contamination. Also, it is possible that impact to the soils within the Shelby tube were restricted to a zone within the core of the sample. If this is the case, there is a chance that high VOC concentrations were not detected during laboratory analysis since soil samples were always removed from the ends of the sample. Mass balance calculations show that much of the VOC removal from the sample occurred via volatilization. However, the two orders of magnitude increase in the numbers of heterotrophic bacteria during the first eight days of the study suggest that biodegradation played a role in the removal of the contaminants. However, the microbial counts declined as the volatile organic constituents and moisture content of the soil decreased.

Introduction of nutrients to the groundwater and circulation through the vadose zone is likely to lead to plugging problems because of the high iron content of the groundwater and the moderately high levels of silt and clay in the soil.

6.0 CONCLUSIONS

Although bioventing appears to be a viable remediation technique for this site, venting alone may be able to reduce the volatile aromatic concentrations to an acceptable level. We also do not recommend that traditional in situ bioremediation be used without additional feasibility tests. TSI reaches the following conclusions about this site:

* The soil contains acceptable numbers of heterotrophic microbes with a substantial portion of hydrocarbon-utilizers.

* It appeared that bioventing would be an effective treatment for these soils. There appears to be sufficient nutrients and moisture in the soil to support biodegradation of the contaminants during bioventing. The bioventing system could be operated with a high air flow rate to remove as much of the volatile contaminants as possible. After the levels of volatile contaminants in the air stream have fallen, the air flow rate in the system could be reduced and biodegradation promoted.

* Introduction of nutrients to the groundwater and circulation through the vadose zone does not seem to be practical for this site.

TABLES

Table 1

Inorganic Nutrients in Quebecor Soil		
Compound	Units	MVTL
Nitrate-Nitrogen	ppm	2.6
[illegible]		
Total Kjeldahl Nitrogen	mg/l	220
Phosphorus	ppm	5
Potassium	ppm	10
Zinc	ppm	0.5
Sulfate-Sulfur	ppm	26
pH		6.6
Calcium	ppm	800
Magnesium	ppm	150
Boron	ppm	0.2
Iron	ppm	67.2
Maganese	ppm	4.9
Copper	ppm	0.7
Sodium	ppm	13
CEC	ppm	5.3
Organic Matter	%	2.3
Salts	mmhoss/cm	0.2
Texture		Med/Fine

Table 2

Particle Size Analysis	
Fraction	Percent
Gravel	9.45
Coarse Sand	4.16
Medium Sand	19.21
Fine Sand	54.32
Clay and Silt	13.41

TABLE 3		
MICROBIAL COUNTS		
Soil Sample Day	TOTAL COUNT NUTRIENT AGAR	HYDROCARBON UTILIZER MINERAL AGAR
0	1.8×10^6	2.8×10^6
8	1.8×10^8	2.5×10^6
15	2.4×10^7	1.2×10^6
28	3.9×10^7	8.0×10^5
42	2.7×10^7	No Data Available

Sample Description: Bioventing Feasibility Study -- Quebecor, Inc.

TABLE 4					
BTEX CONCENTRATIONS					
Soil (ug/kg*)					
COMPOUND	TIME				
	DAY 0	DAY 8	DAY 15	DAY 28	DAY 42
Benzene	< 0.6	<300	<0.5	<0.6	<0.5
Toluene	38	<300	5.3	6.2	3.8
Ethyl Benzene	18	<300	<0.5	<0.6	<0.5
Meta & Para-Xylene	39	700	2.9	4.3	<0.5
Ortho-Xylene	7.5	<300	7.8	4.0	<0.5
Activated Carbon (ug/kg*)					
COMPOUND	TIME				
	DAY 0	DAY 8	DAY 15	DAY 28	DAY 42
Benzene**			48000		21000
Toluene			1100000		260000
Ethyl Benzene			23000		53000
Meta & Para-Xylene			27000		7300
Ortho-Xylene			<13000		<5000

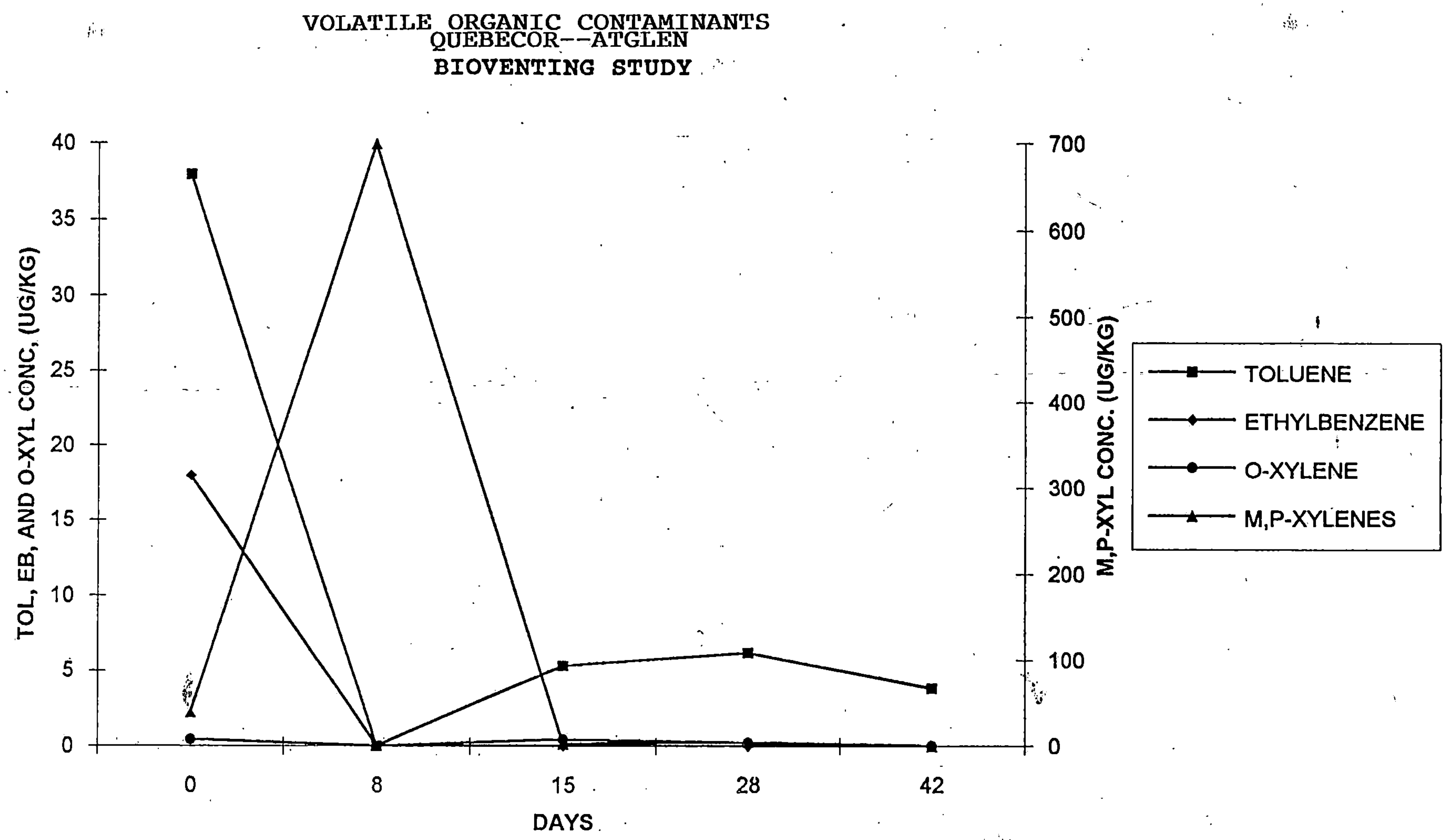
* Dry Weight Basis
** Please refer to Section 5.3 & 5.4

TABLE 5

ESTIMATED QUANTITY OF VOLATILE ORGANIC CONTAMINANTS DURING BIODEGRADATION STUDIES

COMPOUND	SOIL (ug)	SOIL RESIDUAL (ug)	CARBON TRAP (ug)
Benzene	<4.2	<3.5	656
Toluene	266	26.6	12920
Ethyl Benzene	126	<3.5	269
Meta & Para-Xylene	273	<3.5	326
Ortho-Xylene	52	<3.5	<171

FIGURES


VOLATILE ORGANIC CONTAMINANTS
QUEBECOR--ATGLEN
BIOVENTING STUDY
TOL, EB, AND O-XYL CONC, (UG/KG)
M,P-XYL CONC. (UG/KG)
DAYS
0
8
15
28
42
TOLUENE
ETHYLBENZENE
O-XYLENE
M,P-XYLENES

APPENDIX A

VOLATILE ORGANICS ANALYSIS DATA SHEET
(BTEX GC/PID)

LAB SAMPLE # : 67302B
MATRIX : SOIL
CLIENT ID : Quebecor Time 0

DATE ANALYZED : 06/02/1994
DATE RECVD : 05/23/1994

DATA FILE : BTX12006
SAMPLE wt/vol: 5.00 gm
Percent Moisture : 20.2

	COMPOUND	RESULT (ug/kg*)	Detection Limit (ug/kg*)
71-43-2	Benzene	ND	0.6
108-88-3	Toluene	38	0.6
100-41-4	Ethyl Benzene	18	0.6
106-42-3	Meta & Para-Xylene	39	0.6
95-47-6	Ortho-Xylene	7.5	0.6

ND Not Detected
B Analyte Also found in blank
D Diluted
E Estimated

* Dry Weight Basis
i.ie15/btx.id/1.253

VOLATILE ORGANICS ANALYSIS DATA SHEET
(BTEX GC/PID)

LAB SAMPLE # : 67650
MATRIX : SOIL
CLIENT ID : Biovent-Day 8

DATE ANALYZED : 06/02/1994
DATE RECVD : 05/31/1994

DATA FILE : BTX12012
SAMPLE wt/vol: 0.01 gm
Percent Moisture : 16.2

	COMPOUND	RESULT (ug/kg*)	Detection Limit (ug/kg*)
71-43-2	Benzene	ND	300
108-88-3	Toluene	ND	300
100-41-4	Ethyl Benzene	ND	300
106-42-3	Meta & Para-Xylene	700	300
95-47-6	Ortho-Xylene	ND	300

ND Not Detected
B Analyte Also found in blank
D Diluted
E Estimated

* _ry Weight Basis
file21/btx.id/596.659

VOLATILE ORGANICS ANALYSIS DATA SHEET
(BTEX GC/PID)

LAB SAMPLE # : 68053
MATRIX : SOIL
CLIENT ID : Biovent-Day 15

DATE ANALYZED : 06/14/1994
DATE RECVD : 06/07/1994

DATA FILE : BTX17014
SAMPLE wt/vol: 5.00 gm
Percent Moisture : Not Found

COMPOUND		RESULT (ug/kg*)	Detection Limit (ug/kg*)
71-43-2	Benzene	ND	0.5
108-88-3	Toluene	5.3	0.5
100-41-4	Ethyl Benzene	ND	0.5
106-42-3	Meta & Para-Xylene	2.9	0.5
95-47-6	Ortho-Xylene	7.8	0.5

ND Not Detected
B Analyte Also found in blank
D Diluted
E Estimated

* Dry Weight Basis
file14/btx.id/1.000

Raytheon
Engineers & Constructors

VOLATILE ORGANICS ANALYSIS DATA SHEET
(BTEX GC/PID)

LAB SAMPLE # : 68364
MATRIX : SOIL
CLIENT ID : Quebecor-Day 28

DATE ANALYZED : 06/27/1994
DATE RECVD : 06/13/1994

DATA FILE : BTX24013
SAMPLE wt/vol: 5.00 gm
Percent Moisture : 16.6

COMPOUND		RESULT (ug/kg*)	Detection Limit (ug/kg*)
71-43-2	Benzene	ND	0.6
108-88-3	Toluene	6.2	0.6
100-41-4	Ethyl Benzene	ND	0.6
106-42-3	Meta & Para-Xylene	4.3	0.6
95-47-6	Ortho-Xylene	4.0	0.6

ND Not Detected
B Analyte Also found in blank
D Diluted
E Estimated

* Dry Weight Basis
file13/btx.id/1.199

AR340300

VOLATILE ORGANICS ANALYSIS DATA SHEET
(BTEX GC/PID)

LAB SAMPLE # : 69167
MATRIX : SOIL
CLIENT ID : Quebecor Day 42

DATE ANALYZED : 06/29/1994
DATE RECVD : 06/27/1994

DATA FILE : BTX26011
SAMPLE wt/vol: 5.00 gm
Percent Moisture : Not Found

	COMPOUND	RESULT (ug/kg*)	Detection Limit (ug/kg*)
71-43-2	Benzene	ND	0.5
108-88-3	Toluene	3.8	0.5
100-41-4	Ethyl Benzene	ND	0.5
106-42-3	Meta & Para-Xylene	ND	0.5
95-47-6	Ortho-Xylene	ND	0.5

ND Not Detected
B Analyte Also found in blank
D Diluted
E Estimated

* Dry Weight Basis
f 11/btx.id/1.000

VOLATILE ORGANICS ANALYSIS DATA SHEET
(BTEX GC/PID)

LAB SAMPLE # : 68054
MATRIX : SOIL
CLIENT ID : Carbon-Day 15

DATE ANALYZED : 06/16/1994
DATE RECVD : 06/07/1994

DATA FILE : BTX19015
SAMPLE wt/vol: 0.00 gm
Percent Moisture : Not Found

	COMPOUND	RESULT (ug/kg*)	Detection Limit (ug/kg*)
71-43-2	Benzene	48000	13000
108-88-3	Toluene	1100000	13000
100-41-4	Ethyl Benzene	23000	13000
106-42-3	Meta & Para-Xylene	27000	13000
95-47-6	Ortho-Xylene	ND	13000

ND Not Detected
B Analyte Also found in blank
D Diluted
E Estimated

Dry Weight Basis
e15/btx.id/25000.000

18615

VOLATILE ORGANICS ANALYSIS DATA SHEET
(BTEX GC/PID)

LAB SAMPLE # : 69168
MATRIX : SOIL
CLIENT ID : Quebecor Carbon

DATE ANALYZED : 06/29/1994
DATE RECVD : 06/27/1994

DATA FILE : BTX26012
SAMPLE wt/vol: 0.0005 gm
Percent Moisture : Not Found

	COMPOUND	RESULT (ug/kg*)	Detection Limit (ug/kg*)
71-43-2	Benzene	21000	5000
108-88-3	Toluene	260000	5000
100-41-4	Ethyl Benzene	5300	5000
106-42-3	Meta & Para-Xylene	7300	5000
95-47-6	Ortho-Xylene	ND	5000

ND Not Detected
B Analyte Also found in blank
D Diluted
E Estimated

* Dry Weight Basis
)12/btx.id/10000.000

VOLATILE ORGANICS ANALYSIS DATA SHEET
(BTEX GC/PID)

LAB SAMPLE # : 69166D
MATRIX : WATER
CLIENT ID : RW-1 Influent

DATE ANALYZED : 06/29/1994
DATE RECVD : 06/27/1994

DATA FILE : BTX26013
SAMPLE wt/vol: 0.50 ml

COMPOUND		RESULT (ug/L)	Detection Limit (ug/L)
71-43-2	Benzene	22	5.0
108-88-3	Toluene	52000 D	5.0
100-41-4	Ethyl Benzene	460	5.0
106-42-3	Meta & Para-Xylene	1200 D	5.0
95-47-6	Ortho-Xylene	410 D	5.0

ND Not Detected
B Analyte Also found in blank
D Diluted
E Estimated

file13/btx.id/10.000

MVTL LABORATORIES, Inc.

SOIL TEST REPORT

NEW ULM, MN PH. 507-354-8517 | NEVADA, IA PH. 515-382-5486 | GRAND FORKS, ND PH. 701-746-8335

SUBMITTED BY: 23995 RRA SYSTEMS INC DICK RAYMOND - SUITE E 1035 PHILADELPHIA PIKE WILMINGTON, DE 19809-2039	DATE RECEIVED: 05-25-94 DATE REPORTED: 05-27-94 WORK ORDER NO: 11-0712 LAB NOS: 1009-930	SUBMITTED FOR: QUEBECOR

V8.23 940426 | SAMPLE ID TIME 0 | PREV. CROP | SAMPLE ID | PREV. CROP

		V - LOW / LOW / MED / HIGH / V - HIGH		V - LOW / LOW / MED / HIGH / V - HIGH
ORGANIC MATTER	2.3%			N
NITROGEN (NO_3-N) LBS/A	5	(0-6") 2.6 ppm		
PHOSPHORUS (P) PPM BRAY 1	5			W E
PHOSPHORUS (P) PPM OLSEN	7			
POTASSIUM (K) PPM	10			
ZINC ppm	.5			
SULFUR (SO_4- S) ppm	26.0			S
ACIDITY pH	6.6	B ppm / Fe ppm / Mn ppm / Cu ppm / Na ppm		B ppm / Fe ppm / Mn ppm / Cu ppm / Na ppm
BUFFER INDEX		.2(L) / 67.2(S) / 4.9(S) / .7(S) / 13		
		SALTS mmhos/cm .2 / TEXTURE MED/FINE		SALTS mmhos/cm / TEXTURE
CALCIUM PPM	800.0	CEC / % BASE SATURATION: Ca / Mg / K / Na / H		CEC / % BASE SATURATION: Ca / Mg / K / Na / H
MAGNESIUM PPM	150	5.3 / 75.2 / 23.2 / .5 / 1.1		

ALL RECOMMENDATIONS ARE ON A BROADCAST BASIS	CROP FERTILIZER RECOMMENDATIONS			CROP FERTILIZER RECOMMENDATIONS		
CROP AND YIELD GOAL	(--)	(--)	ACTUAL			
NITROGEN (lbs/A)						
P_2O_5 (lbs/A) STANDARD						
P_2O_5 (lbs/A) BUILD (B) OR CROP REMOVAL (CR)						
K_2O (lbs/A) STANDARD						
K_2O (lbs/A) BUILD (B) OR CROP REMOVAL (CR)						
ZINC (lbs/A)						
SULFUR (lbs/A)						
LIME NEEDS AS 100% ECCE (lbs/acre) to pH 6.0	No lime required.					
LIME NEEDS AS 100% ECCE (lbs/acre) to pH 6.5	No lime required.					

ADDITIONAL RECOMMENDATIONS AND COMMENTS:

1) There is a possibility of BORON deficiency. This should be confirmed by plant analysis before application.
2) Refer to reverse side for explanation of soil tests and fertilizer recommendations.

GROWER COPY

AR340305

1.0

CHAIN OF CUSTODY DOCUMENTATION

SHIP TO:
Raytheon Engineers & Constructors
301 CHELSEA PARKWAY
BOOTHWYN, PA 19061
(215) 497-6000
(FAX -6005)

CLIENT: Terra Systems
PROJECT DESCRIPTION: Quebecor
SEND REPORT TO: D. Raymond
SEND INVOICE TO:
DATA NEEDED BY: 7/1/94
REPORT NEEDED BY:

LABORATORY JOB NO.: 7575304
SAMPLERS: L. O'SHEA
PHONE: FAX:
REPORT TYPE: TIER I___ TIER II___ STANDARD X QC___ OTHER___

FOR LAB USE ONLY:
P.O. NO.:
DUE DATE:
COOLER SEAL
YES....... NO.......
BROKEN..... INTACT.....
COOLER TEMP.: deg. F

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Sampled in Lab

ANALYSIS REQUIRED: pH 460; TSS 335; Total P TKN 315-; VOA - 6270S

QUOTE NO.:
SUMMARY NO.: 18878

ID.	DATE	TIME	MATRIX	GRAB	COMP.	TYPE	NO.	PRESERVATIVE	pH	pH 460	TSS 335	Total P TKN 315-	VOA - 6270S	LABORATORY NO.
RW-1 Influent	6/25		W	X		Milk Jug	1	NON		X				69166A
RW-1 Inf	"		W	X		500P	1	HNO3 <2			X			69166B
RW-1 InF	"		W	X		250P	1	H2SO4 <2				X		69166C
RW-1 InF	"		W	X		VOA	2	None					X	69166D
Quebecor Dewtz	6/27		S	X		4oz G	1	NON					X	69167
Quebecor Carbon	6/27		M	X		4oz G	1	NON					X	69168

RELINQUISHED BY		RECEIVED BY		METHOD OF SHIPMENT
NAME: OF:	DATE: TIME:	NAME: [signature] OF:	DATE: 6/27/94 TIME:	AIRBILL NO.:
NAME: OF:	DATE: TIME:	NAME: OF:	DATE: TIME:	
NAME: OF:	DATE: TIME:	NAME: OF:	DATE: TIME:	

AR340306

005

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME	ANALYSIS	REMARKS	PRESERVATION
0010 0002	QUEBECOR	PHYSICAL ANAL.		

SAMPLERS: (Signature) Mark D. Hewitt

NO.	DATE	TIME	COMP	GRAB	STATION AND LOCATION	PHYSICAL ANAL.						REMARKS	PRESERVATION
1	25 Jun 94	1235		X	RW-1 INFLUENT	X						Sample for Dick Raymond of Terra Systems	

RELINQUISHED BY:	DATE	TIME	RECEIVED BY:	RELINQUISHED BY:	DATE	TIME	RECEIVED BY:
M D Hewitt	26 Jun 94	1300	[illegible]	Jason W. Henkel	6/27/94	7:15 AM	
RELINQUISHED BY:	DATE	TIME	RECEIVED BY:	RELINQUISHED BY:	DATE	TIME	RECEIVED BY LABORATORY:
[illegible]	6/27/94	2:09 pm	[illegible]				

REMARKS:

DISTRIBUTION: M. SWEITZER

GES Groundwater & Environmental Services, Inc.
410 Eagleview Boulevard • Suite 110
Exton, PA 19341
(215) 458-1077 FAX (215) 458-1081

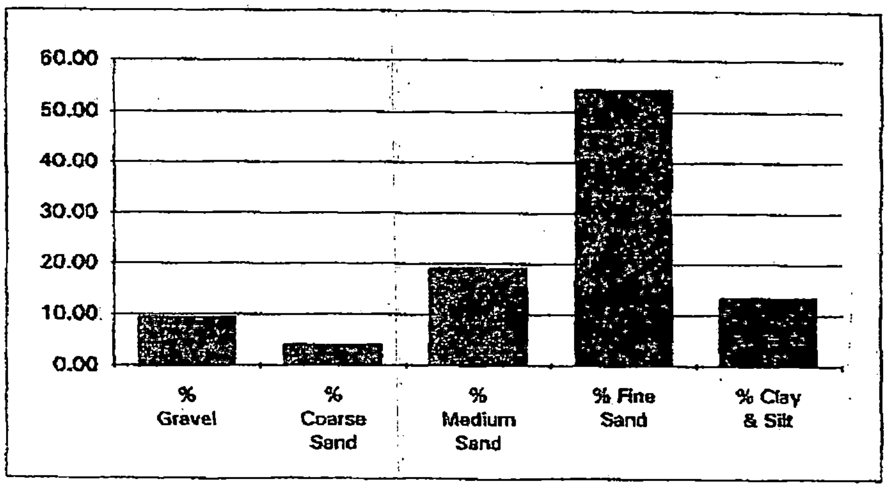
Engineers & Constructors

RE&C ENVIRONMENTAL LABORATORY

PARTICLE SIZE ANALYSIS OF SOILS (AP-Z08/ASTM D422)
Sieve Analysis Only

Client:	Terra Systems		
Project:	Quebecor	Job No. :	7575304
Location:			
Tested By:	LEO	Checked By:	
Lab Sample Log Number:	67302A	Time 0	
Method of Test:	ASTM-D422	Date:	06/30/94

% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Clay & Silt
9.45	4.16	19.21	54.32	13.41



AR340308

APPENDIX E

SUMMARY OF ENGINEERING PRACTICES AND EQUIPMENT DESIGNS UTILIZED TO PROHIBIT FUTURE RELEASES

QUEBECOR PRINTING
ATGLEN INC.

August 5, 1994

G.E.S., Inc.
410 Eagleview Blvd.
Exton, PA 19341

ATTN: SHARON ROBERTS

The following is a brief summary of items incorporated in the construction of our Aboveground Tank Farm to further reduce spill prevention at our facility.

Mechanical Requirements:

1. Pipe/Pipe Fittings - All pipe runs from Area "A" to Area "B" are A53 seamless pipe solid weld contruction. All weld connections are in compliance with ANSI B31.1. All joints are leakproof and tested in accordance with the design pressure specified. All pipe tested with air at pressure of 200 PSIG at min. 8 hrs.

2. Flanges and Gasketing - All other connections are flange connected using a Gortex gasket. The gortex gasket replaces the Spiral-wound Monel due to better sealing abilities and resistence to solvent.

3. Valving - Special valving is being used on 1.5" seamless pipe.
   SP40C1 - Ball Valve with spring return / fail-closed handle.
   SP40C2 - Fire Safety Valve with heat actuated thermal trip and positive shutoff.

4. Load/Unload Pad - Concrete containment pad has been installed for all importing and exporting of solvents, inks and fuel oil. All pipe and meter racks are mounted in contained area. All connections for importing and exporting will be made in the contained area.

5. Aboveground Storage Tanks - Tanks for toluene, lacolene and xylene are double-wall UL 58 Type 1, 360-degree wrap. Interstital monitoring from a tube extending to the top of the tank from a sump at the tank bottom. Tank fill connection provided with a 7 gallon overfill sump. Tanks inspected and leak tested in accordance with UL-142.

AR340310

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Electrical Requirements:

1. Interstital monitoring of all tanks.

2. Multi-point level detection.

3. Electronic comparing of level detection and inventory level to constantly check the volume in the tank.

4. Electronic pump running / flow rate comparison to insure solvent is moving through the pipe system.

5. Automatic shutdown in the event of various system alarm conditions which could cause a problem or cause a situation which is out of the ordinary.

6. Automatic valve closureand pump shutdown should the computer/PLC Controller fail.

7. Wet detection at pump house Area "B" should there be leak or pump failure.

8. Emergency Shutdown push-buttons stategically located for manual shutdown by the operator.

Anyother questions or concerns, please feel free to call.

Sincerely,

Bill Boerstler
PROJECT ENG.

cc: G. Adams
D. Potts

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